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CLINICAL ABORTION AND SEROLOGICAL INVESTIGATION OF *Brucella melitensis, Coxiella burnetii* AND *Toxoplasma gondii* IN GOAT'S IN ATAYE BOER NUCLEUS SITE NORTH SHEWA ZONE, ETHIOPIA

Enyiew Alemnew*, Erdachew Yitagesu, Derib Aydefruhim, Alemnew Areaya

Debre Birhan Agricultural Research Centre, PO. Box 112, Debre Birhan Ethiopia

Abstract. The present study was conducted to determine the rate of abortion and to investigate seroprevalence of major causes of abortion; *Brucella melitensis, Coxiella burnetii* and *Toxoplasma gondii* in goats from January 2016 to December 2018 in Debre Birhan Agricultural Research Center; Ataye Boer Nucleus Site North Shewa, Ethiopia. Data were statistically analyzed by chi-square test using Statistical Package for Social Science (SPSS) software 20.0 version. During three consecutive years of clinical cases study, 513 goats were entered to mating and (19.5%) of the animals aborted. There were a significant difference ($p = 0.013$) in abortion among paritie but no difference ($p>0.05$) among goat's breeds. Serum samples were collected from 35 aborted femals within six months periods. All samples were screened initially with Rose Bengal plate test (RBPT) for *Brucella melitensis*. All RBPT positive were further tested by i-ELISA. Also, serums were tasted for specific antibodys against *Coxiella burnetii* and *Toxoplasma gondii* using i-ELISA. 65.7% and 8.6% of the tested goats were positive for *Coxiella burnetii* and *Toxoplasma gondii* respectively, but neither of them was positive for *B. melitensis*. The present study revealed that *Coxiella burnetii* and *Toxoplasma gondii* were the major causes of abortion in the study site.

Keywords: *Abortion, Boer goat, Brucella melitensis, Clinical, Coxella burnetti, serological investigation, Toxoplasma gondii.*

Corresponding Author: *Enyiew Alemnew, Debre Birhan Agricultural Research Centre, Po. Box 112, Debre Birhan, Ethiopia, Phone: +251927681130, e-mail: alemnewenyiew@gmail.com*

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1. Introduction

Ethiopia is an agriculturally based country and owns a considerable number of small ruminants, which is estimated to be over 61 million heads of sheep and goats (CSA, 2017). Despite these large small ruminant population sizes, the country failed to optimally utilize these resources as the sector is suffering lower productivity due to various factors in which diseases stand front line (Mohammed *et al.*, 2017). One of the diseases that hamper the productivity of small ruminants is abortion, which has major economic and public health impacts (Mohammed *et al.*, 2017).

Reproductive diseases that result in abortion impose great economical loss in productivity and by product of small ruminants (Mohammed *et al.*, 2017). The common diseases that cause abortion both in goats and sheep in sub-Saharan countries are Brucellosis, Campylobacteriosis Vibriosis, Chlamydiosis, Foot and Mouth Disease (FMD), Listeriosis, Q-fever, malnutrition, Nairobi Sheep Disease, Rift Valley Fever, Salmonellosis Trypanosomiasis (OIE, 2018; Ali *et al.*, 2019) and Toxoplasmosis (Peters, 1994; Dubey, 2010). Non-infectious causes of abortion like poisoning,

malnutrition, stress, inherited abortion, vitamin and mineral imbalances brings great loss in production of small ruminant (Peters, 1994).

Several diseases in small ruminants cause abortion or reduced fertility (Szeredi *et al.,* 2006; Mohammed *et al.,* 2017). Toxoplasmosis is zoonotic disease caused by an obligate intracellular parasite known as *T. gondii* (Dubey, 2010). It is the most prevalent parasitic infections in human and veterinary medicine and has negative impacts on public health and animal production. *T. gondii* is believed to be the most triumphant parasitic pathogen in large scale (Dubey, 2010). From wide range of farm animals, sheep and goats are more commonly infected with *T. gondii* than cattle and chicken. This parasite causes abortion and neonatal death in major monetary losses to sheep, goat and pig farming (Tenter, 2000; Jithendran, 2004). This is more serious especially when primary infection occurs during pregnancy (Radostits *et al.,* 2006). During the past decades, *Toxoplasmosis* was reported in different parts of Ethiopia; 35% in Debre Birhan and surrounding areas (Demissie and Tilahun, 2002), 19.7% in East and West Shewa Zones, Oromia Regional State (Zewdu *et al.,* 2013), 15.1% in sheep and goats slaughtered for human consumption in Central Ethiopia (Endrias and Daniel, 2014), 70.83% in Menz and Horo areas (Gebretensay *et al.,* 2019) and 10.25% in small ruminant in Abergele and Ziquala, Amhara Region (Bahiru *et al.,* 2020).

Q-fever is a zoonotic disease caused by *Coxiella burnetii*. Livestock (cattle, sheep, camels and goats) are the main reservoirs of infection to humans (Kaabia and Letaief, 2009; Angelakis and Raoult, 2010). It is also known as an occupational disease of veterinarians, farmers and abattoir workers (De Rooij *et al.,* 2012). *Coxiella burnetii*, the causative agent has been isolated from ticks. Q-fever is frequently misdiagnosed by physicians (Kaabia and Letaief, 2009). It is endemic, both in livestock and humans in North and Sub-Saharan Africa (Schelling *et al.,* 2003; Steinmann *et al.,* 2005; Mazyad and Hafez, 2007). In Ethiopia, the existence of antibody against *C. burnetii* was reported in goats and sheep slaughtered at Addis Ababa abattoir, and it's peri-urban zone (Philip *et al.,* 1966; Gebremedhin *et al.,* 2014). Also seroprevalence of *T.gondii* in small ruminant was reported in Abergelle and Zequala Amhara Region (Bahiru *et al.,* 2020). The diagnosis of *Coxiella burnetii* infection in animals has a great importance to identify the infected flocks and to determine the risk of disease transmission to humans (OIE, 2015; Ullah *et al.,* 2018).

Brucellosis is an animal's disease, especially livestock (cattle, goats, sheep, camels and pigs), but also wild animals (Awah-Ndukum *et al.,* 2018*).* It is caused by *Brucella spp.* In livestock, it is primarily a reproductive disease characterized by late abortion, retained fetal membranes, Orchitis and impaired fertility (Zinsstag *et al.,* 2011). *B. melitensis* is considered to have the highest zoonotic potential, followed by *B. abortus*, and *B. suis* (Radostits *et al*., 2007). In Ethiopia, serological studies on brucellosis have been carried out in small ruminant; 9.6% in Southeast Pastoral Livestock (Balako *et al.,* 2013), 1.56% in Yabello districts (Debassa *et al.,* 2013), zero serorevalence in Menz and Horo areas (Gebretensay *et al.,* 2019) and in Abergele and Ziquala, Amhara Region (Bahiru *et al.,* 2020).

During the *peri-partum* period, the massive multiplication of *C. burnetii* and *Brucella melitensis* occurs within trophoblast cells, causing necrotic suppurative placentitis, which ultimately leads to pregnancy failure in the form of abortion, stillbirth, premature birth of weak offspring (Sanchez *et al.,* 2006; Arserim *et al.,* 2011). There were frequent challenges of abortion, stillbirth, retained placenta, premature birth of weak kids in different goat breeds in Ataye Boer Nucleus Site; Debre Birhan

Agricultural Research Centre, Ethiopia (Alemnew *et al.*, 2020a). Also full-term kids were also weak, with low body weight and high mortality (Alemnew *et al.*, 2020b). Therefore the aims of the present study were to determine the rate of abortion and to estimate the seroprevalence of *B. melitensis, Coxiella burnetii* and *Toxoplasma gondii* in the study flocks kept in Ataye Boer Nucleus site, North Shewa, Ethiopia.

2. Materials and methods

Description of study area

A longitudinal clinical case study on abortion in different goat breeds was conducted in Debre Birhan Agricultural Research Center, *Ataye* Boer goat Nucleus Site from June 2015 to September 2019. The site is found 5km far from *Ataye* town, Eastern Amhara Regional state of Ethiopia and 250 km from Addis Ababa. *Ataye's* climate is classified as tropical. At an average temperature of 25.4 °C, June is the hottest month of the year. December has the lowest average temperature of the year which is 18.7 °C. The climate is characterized by bimodal rainfall consisting of the long rainy season (June-September), short rainy season (February-May), and dry season (October-January). In a year, the average rainfall is 1085 mm (Fekadu, 2015).

Animal's management

The genotypes of the goats evaluated were pure Boer, Central Highland Goat, and 50% Boer (pure Boer cross with Central Highland Goat). A total of 513 goats were used to assess the rate of abortion from June 2015 to September 2019. Flocks were reared with two categories of feeding management i.e. intensive and semi-intensive. Pure Boer goats were managed under intensive management system and 50% Boer and Central Highland Goat were managed under semi-intensive system with grazing and a supplement. The supplement includes *adlibitum grass* hay, chopped pasture (Napier grass, *Desmodium species* and vetch) and commercial concentrate supplement based on their body weight.

Animals were treated using anthelmintic drugs that include albendazole, tetraclozash, tetramisole, ivermectin and triclabendazole. The drugs were applied in three rounds per year in October, February and June following manufacturers' recommendations and deworming months were selected based on the epidemiological cycle of targeted parasite groups and the laboratory findings. Also animals in on-station were sprayed against ectoparasites (ticks, mites, fleas and lice) by using diazinon (60%) and amitrazine (12.5%) and regular vigilance was performed to ensure feeding, herd health care, proper breeding, and cleanliness of the farm (Alemnew *et al.*, 2020a). They were also vaccinated against major infectious diseases which include ovine pasteurellosis (two times per year on October and April), sheep and goat pox (one per year on May), peste des petitis ruminants' /PPR/ small ruminant plague (one per year on September) and contagious caprine pleura pneumonia (one per year on September).Regular vigilance was performed to ensure feeding, herd health care, proper breeding, and cleanliness of the farm.

Study design and sample collection

Abortions were diagnosed up on clinical and post-mortem examination. Aborted animals were grouped based on breeds (Pure Boer, 50% Boer and Central Highland Goat) and round of parity (1^{st}, 2^{nd}, 3^{rd}, 4^{th} and > = 5^{th} Days).

Blood samples were collected directly from the jugular vein using sterile vacutainers, about 5 ml of blood was collected. Each sample was labeled using codes describing the specific animal. The tubes were kept overnight at a room temperature to allow clotting. Next morning the serums were separated from blood and collected into 1.8 ml cry vial and were preserved at -20ºC until they were processed.

All samples were initially tested by Rose Bengal Test (RBPT), by using30 µl of serum and 30 µl of antigen (Rose Bengal stained B. abortus antigen obtained from BIO-RAD, Marnes-la- Coquette, France) it was mixed and rotated on a glass plate for 4 minutes. Samples with no visible agglutination were recorded as negative, while those showing agglutination were considered positive. For further analysis, all RBPT-positive samples were tested by using i-ELISA kits for *Brucella melitensis*. ELISA kit was obtained from ID Screen® Brucellosis Serum Indirect Multi-species (ID Vet innovative diagnostic Grabels, France). The sensitivity and specificity of the ELISA test kit as provided by the manufacturer were 100% and 99.74%, respectively. The tests were performed according to manufacturer's instructions (OIE, 2009).

All samples were tested against specific antibodies to *C. burnetii* using indirect enzyme-linked immunosorbent assay (I-ELISA). The test use microtiter plates pre-coated with the *C. burnetii* phase I and II strains (ID Screen® Q Fever Indirect Multi-Species, IDvet®). Positive and negative control samples were included in each plate. The sensitivity and specificity of the ELISA test kit as provided by the manufacturer was 99% and 98%, respectively. The test was conducted according to the manufacturer protocol.

Also the samples were tested by using indirect ELISA test using ID Screen Toxoplasmosis Indirect Multispecies manufactured by ID vet, France with wells coated with P30 *T. gondii* antigen to detect the anti-Toxoplasma antibody. The sensitivity and specificity of the ELISA test kit as provided by the manufacturer was 100%. The samples were analyzed in Ethiopian Institute of Agricultural Research; National Agricultural Biotechnology Research Centre.

Data management and statistical analysis

Collected data were recorded in MS excel work sheet, after they were checked manually for obvious inconsistencies, recording errors or missing data. Data were analyzed using IBM SPSS V.20 software version. Descriptive statistics were used to determine the rate of abortion and sero-prevalence of *Brucella melitensis, C. burnetti* and *T. gondii* in goats. Univariable logistic regression analyses (LR) was also used to measure the level of association between the possible associated risk factors and clinical abortion. A significance level ($p<0.05$) and confidence level (95%) was set to determine the presence or absence of statistically significant difference between the given parameters.

3. Results

During the study periods 513 goats were assigned for mating, 100 goats (19.5%) aborted. Higher rate of abortion were recorded in the second parturition with 50%, Boer goats with rate of 35.1% and 22.8%, respectively (Table 1).

Table 1. Abortion rate in different goat breeds and parities at Ataye Boer Goat Nucleus Site North Shewa, Ethiopia

Variables		**No. does**	**No. aborted**	Abortion **rate (%)**
Breed	Pure Boer	104	22	21.2
	50% Boer	197	45	22.8
	CHG*	212	33	15.6
Parities	1st	104	25	24.0
	2nd	77	27	35.1
	3rd	114	9	7.9
	4th	113	14	12.4
	>= 5th	105	25	23.8
Total		513	100	19.5

Note: CHG = Central Highland Goat

Table 2 showed that the association between different risk factors and abortion. There were a significant difference in clinical abortion between 1st (28.1%) and >=5th (40.3%) parturition (p = 0.046, OR = 2.5). Even though there was no statistical difference between first and 2nd and 4th parturition and were about 1.6 and 2 times higher than first party, respectively. There was no statistical difference (p > 0.05) in clinical abortion among different goat breeds.

Table 2. Univariable logistic regression analyses (LR) of risk factors (breed and round party) and abortion at Ataye Boer Goat Nucleus Site North Shewa, Ethiopia

Risk factors		**No. does conceived**	**No. does aborted (%)**	***p*-value**	**OR**	**Confidence interval (95%)**
Breeds	Pure Boer*	57	22 (38.6)	-	-	-
	CHG	139	33 (23.7)	.157	.603	.300 – 1.214
	50% Boer	128	45 (35.2)	.637	1.223	.531 – 2.816
Parities	1st*	89	25 (28.1)	-	-	-
	2nd	65	27 (41.5)	.055	1.959	.985 – 3.894
	3rd	57	9 (15.8)	.494	.716	.275 – 1.864
	4th	51	14 (27.5)	.341	1.595	.611 – 4.163
	>= 5th	62	25 (40.3)	.046	2.504	1.015 – 6.175
Total		324	100 (30.9)			

Note: * Reference category; CHG = Central Highland Goat

In the present study a total of 35 serum samples were collected from aborted goats within six month periods, 23 (65.7%) and 3 (8.6%) animals were positive for *Coxiella burnetii* and *Toxoplasma gondii* antibody, respectively. But, all animals tested were negative for *B. melitensis* (Table 3).

Table 3. Seroprevalence of *Brucella melitensis*, *Coxiella burnetii* and *Toxoplasma gondii* in does at Ataye Boer Goat Nucleus Site North Shewa, Ethiopia

Types of Diseases	**No. Animal Examined**	**No. Animal Positive**	**Apparent seroprevalence (%)**
Brucella melitensis	35	0	0.0
Coxiella burnetii	35	23	65.7
Toxoplasma gondii	35	3	8.6
Total	105	26	24.8

4. Discussions

Abortion imposes great economical loss in productivity in small ruminants. Clinical study on the prevalence of abortion in goats had been conducted at different times in various countries. The result of the present study conducted in selected Ataye Boer Nucleus Site Debre Birhan Agricultural Research Centre, Ethiopia, showed an overall rate of clinical abortion in goats of 19.5%. This rate of clinical abortion indicated the wide distribution of abortion caused by infectious and/or non-infectious agents in goats in the study site.

During the past years, clinical analysis of abortion were reported in Ethiopia; Zegeye *et al.* (2014) in Sirinka Agricultural Research Center, Sheep and Goat Breeding, Evaluation and Distribution Site, Bahiru *et al.* (2020) in sheep and Goats of Abergelle and Ziquala Districts of Amhara Region, Northern Ethiopia, Yizengaw *et al.* (2020) in Sirinka Agricultural Research Centre, Amhara Region and Alemnew *et al.* (2020a) in Debre birhan Agricultural Research Center, Sheep and Goat Breeding, Evaluation and Distribution Site,Ethiopia. The current rate of clinical abortion in this study was comparable with 15.8% reported by Hemayatul *et al.* (2015) in Northern Barind Tract and 22% reported by Ahammad *et al.* (2015) in five upazillas of Mymensingh district in Bangladesh. However, the prevalence of abortion in the present study was higher than 1.4% reported by Innocent *et al.* (2015) at the state veterinary hospital maiduguri, Nigeria. The finding in this study was much lower than the findings of Ahmed *et al.* (2008) with 43.7% in Black Bengal goats in Bangladesh. Such inconsistency in the rates of abortion may be due to the variation in the susceptibility of different breeds to diseases causing abortion, management practices, distribution and causing agents, and measures taken to control the diseases.

The parity was related to abortion in present study with a significant difference ($p< 0.05$) between parities, where the 5^{th} parity were about 2.5 times more likely to be aborted as compared to the first one. In this study, older animals presented a higher risk to infect with abortion causing agents then younger animals. In this regard, our result was consistent with Klaasen *et al.* (2014) findings, where the age of the animals was the most significant risk factor for seropositivity of *Q-fever*. Similarly, Gebremedhin *et al.* (2014); Tegegne *et al.* (2016) and Berhanu *et al.* (2018) reported a statistical difference for seropositiv *Toxoplasmosis* and the age of animals.

There was no statistical difference ($p>0.05$) in the rate of abortion among different goat breeds. This might be due to the management type of animals. Our results confirm Berhanu *et al.* (2018) reports, where no statistical differences were observed among different breeds of goats and sero-positivity of *Toxoplasmosis*.

No seroprevalence of *B. melitensis* was observed in this study, whitch is comparable with the findings of Muma *et al.* (2006) with 0% in livestock-wildlife interface areas of Zambia, Debassa *et al.* (2013) 1.56% in small ruminants in the Yabello district, Ethiopia, Tadesse (2016) 2.7% overall pooled prevalence of brucellosis in goats in Ethiopia, Gebretensay *et al.* (2019) 0% in goats, Bahiru *et al.* (2020) 0% in small ruminant in Abergelle and Ziquala, Ethiopia. However, the sero-prevalence results of the present study was much lower than of the previous reports of Teshale *et al.* (2006) 13.2% from Somali region, Ashenafi *et al.* (2007) 5.8% in the pastoral region of Afar, eastern Ethiopia, Megersa *et al.* (2010) 12.4% from Borena pastoralist, and Balako *et al.* (2013) 9.6% in Southeast Ethiopian pastoral livestock. The difference in

the management system used in the different countries, types of samples and laboratory test, sampling methods and/or absence of infected goat herds may attribute to such variations. In addition, those differences might be due to variations of the study areas. *Brucella* transmission is favored by a more humid climate, which prolongs the survival of the bacteria in the environment (Teklye & Kasali, 1989).

The seroprevalence of 65.7% of *C. burnetii* in this study was comparable with the findings of Balako *et al.* (2013) 54.2% in Southeast Ethiopian pastoral livestock and Gebretensay *et al.* (2019) 68.33% in Menz and Horo areas, Ethiopian. However, the sero-prevalence results of the present study was higher than the previous reports of Nakoune (2004) with 14.3% in Central African Republic, Schelling *et al.* (2003) 7% in nomadic pastoralists and their livestock in Chad, Klaasen *et al.* (2014) 24.2% in Gambia, and Qudrat *et al.* (2019) 15.0% in Punjab, Pakistan. These variations in the prevalence in different geographical areas can be associated with the farm hygienic measures, routine management practices and environmental factors such as vegetation, soil moisture and the presence of infected animals and vectors in the surroundings (Paul *et al.,* 2012; Rizzo *et al.,* 2016). Our study showed a higher sero-prevalence in goats, which suggests that Q fever, had a considerable importance in animal population in the studied area. The highest seroprevalence observed in this study may be due to genetic susceptibility of goats to *C. burnetii*, higher prevalence of tick vectors to goats, grazing management where animals shared common graze and watering points, agent could be transmitted though aerosol and/or prevailing climatic and weather conditions in the study site.

The seroprevalence of 8.6% of *T. gondii* in this study was comparable with the findings of Bahiru *et al.* (2020) who reported 10.25% in small ruminant in Abergele and Ziquala, Ethiopia. However, the seroprevalence of *Toxoplasma gondii* in this study was higher than the report of Kamani (2010) with 4.6% from goats in Nigeria and was much lower than many reports in Ethiopia as 35% by Demissie and Tilahun (2002), 24.1% by Negash et al. (2004) using MDAT and 25.9% using ELISA, 74.8% by Teshale et al. (2007), 19.7% by Zewdu et al. (2013), 15.1% by Endrias and Daniel (2014), 15.5%, by Gebremedhin et al. (2014), 55.2% by Tegegne et al (2016), 27.6% by Berhanu et al. (2018), and 70.83% by Gebretensay et al. (2019) in Menz and Horo areas.

Also, the present finding was lower than other reports as 26.8% in Ghana (Van Der Puije *et al.,* 2000), 31% in Uganda (Bisson *et al.,* 2000), 27.9% in Thailand (Jittapalapong *et al.,* 2005) and 19.3% in Tanzania (Swai and Kaaya 2013), and as well as 59.4% (Barakat *et al.,* 2009) and 44.3% (Shaapan *et al.,* 2010) in Egypt. The wide variation in the seroprevalence of *T. gondii* infection can be due related to difference in sample size, types of study design conducted, agro-ecology, climate, carnivorous density, farm hygienic practices, animal management, type of serological tests used and the cut-off value used (Dubey, 2010; Opsteegh *et al.,* 2010).

5. Conclusion

In the current study, abortion was the major constraint of kid loss with 19.5% in goats. The significant risk factor associated with abortion was parity. Serological investigation of antibody against *Coxiella burnetii* and *Toxoplasma gondii* showed that these agents were the major causes of abortion in the study site. Serological survey highlights the importance of clinical herd health management to avoid economic losses in animals.

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References

Ahammad, S., Rashedul, I., Rakesh, K.Y., Rupaly, A. & Jalal, U.A. (2015). Prevalence of different reproductive disorders of small ruminants in five upazillas of Mymensingh district Bangladesh. *Asian Journal of Medicine and Biology Research, 1*(1), 74-79.

Ahmed, Y.F., Sokkar, S.M., Desouky, H.M. & Soror, A.H. (2008). Abortion due to Toxoplasmosis in small ruminants. *Global Veterinaria*, 2, 337-342.

Alemnew, E., Yitagesu, E., Addis, H. & Areaya, A. (2020a). Retrospective epidemiological study on goat disease in Debre Birhan Agricultural Research Center Ataye Boer Breeding, Evaluation and Distribution Site, North Shoa, Ethiopia. *Biomedicine and Nursing, 6*(1), 1-10.

Alemnew, E., Yitagesu, E., Goshme, S. & Aydefruhim, D. (2020b). Retrospective study on kid mortality and associated risk factors of kid survival of newly introduced Boer goat breed in North Shewa Ethiopia. *Livestock research for rural development, 32*(7).

Ali, S., Zhao, Zh., Zhen, G., Zi Kang, J. & Zi Yi, P. (2019). Reproductive problems in small ruminant (sheep and goats): a substantial economic loss in the world. *Large Animal Review*, 25, 215-223.

Angelakis, E., Raoult, D. (2010). Q Fever. *Veterinary Microbiology*, 140, 297–309.

Arserim, N.B., Yesilmen, S., Tel, O.Y., Ozekinci, T., Keskin, O., Pulat, H. & Vural, A. (2011). Seroprevalance of coxiellosisin cows, sheep, goats and humans in Diyarbakir region of Turkey. *African Journal of Microbiology Research*, 5, 2041–2043.

Ashenafi, F., Teshale, S., Ejeta, G., Fikru, R., Laikemariam, Y. (2007). Distribution of brucellosis among small ruminants in the pastoral region of Afar, eastern Ethiopia. *Revue Scientifique Technique*, 26, 731–739.

Awah-Ndukum, J., Mouiche, M.M.M., Bayang, H.N., Ngu Ngwa, N., Assana, E., Feussom, K. J.M., Manchang, T.K., Zoli, P.A. (2018). Seroprevalence and Associated Risk Factors of Brucellosis among Indigenous Cattle in the Adamawa and North Regions of Cameroon. *Vet. Med. Int*., 3468596.

Bahiru, A., Assefa, A., Alemu, B., Desta, H., Wieland, B. & Sahle, A. (2020). A Case Control Study of Infectious and Non-Infectious Causes of Abortion in sheep and Goats of Abergelle and Ziquala Districts of Amhara Region, Northern Ethiopia. Proceedings of the *12th Annual Regional Conference on Completed Livestock Research Activities*, Bahir Dar, Ethiopia.

Barakat, A.M.A., AbdElaziz, M.M. & Fadaly H.A. (2009). Comparative diagnosis of toxoplasmosis in Egyptian small ruminants by indirect hemagglutination assay and ELISA. *Global Veterinaria, 3*(1), 09-14.

Bisson, A.S., Maley, C.M., Rubaire-Akiiki, J. & Watling, M. (2000). The seroprevalence of antibodies to Toxoplasma gondii in domestic goats in Uganda. *Acta Tropica*, 76, 33-38.

CSA. (2017). Federal democratic republic of Ethiopia central statistical agency: Agricultural sample survey 2016/17 (Vol. II). Addis Ababa, Ethiopia.

De Rooij, M.M.T., Schimmer, B., Versteeg, B., Schneeberger, P., Berends, B.R. (2012). Risk factors of Coxiella burnetii (Q fever) seropositivity in veterinary medicine students. *PLoS One*, 7:e32108.

Debassa, G., Tefera, M., & Addis, M. (2013). Small ruminant brucellosis:serological survays in yabello district, Ethiopia. *Asian Journal of Animal Science, 7*(1), 14-21.

Demissie, T., Tilahun, G. (2002). Study on toxoplasmosis in sheep and goats in Debre Birhan and surrounding areas in Ethiopia. *Bulletin of Animal Health and Production in Africa*, 50, 138-147.

Dubey, J.P. (2010). *Toxoplasmosis of Animal and Humans*. Boca Raton, Florida: Second Edition. CRC Press, 1-338.

Endrias, Z.G., Mukarim, Ab., Tsehaye, H. & Tesfaye, S. Te. (2014). Seroprevalence and risk factors of Toxoplasma gondii infection in sheep and goats slaughtered for human consumption in Central Ethiopia. *BMC Research Notes* 2014(7), 696 http://www.biomedcentral.com/1756-0500/7/696.

Fekadu, K. (2015). Ethiopian seasonal rainfall variability and prediction using canonical correlation analysis (CCA). *Earth Sciences 4*(3), 112–119.

Gebremedhin, E.Z., Daniel, G. (2014). Seroprevalence of *Toxoplasma gondii* Infection in Sheep and Goats in Three Districts of Southern Nations, Nationalities and Peoples' Region of Ethiopia. *World Applied Sciences Journal, 31*(11), 1891-1896.

Gebretensay, A., Alemayehu, G., Rekik, M., Alemu, B., Haile, A., Rischkowsky, B. & Wieland B. (2019). Risk factors for reproductive disorders and major infectious causes of abortion in sheep in the highlands of Ethiopia. *Small Ruminant Research*, 177, 1–9.

Gumi, B., Firdessa, R., Yamuah, L., Sori, T., Tolosa, T., Aseffa, A., ... & Schelling, E. (2013). Seroprevalence of brucellosis and Q-fever in southeast Ethiopian pastoral livestock. *Journal of Veterinary Science & Medical Diagnosis*, *2*(1).

Islam, M.H., Sarder, M.J.U., Rahman, M.S., Haque, M.A., Islam, M.A., Jahan, S.S., & Khaton, R. (2015). Retrospective study of reproductive diseases of small ruminants in northern barind tract in Bangladesh. *Animal and Veterinary Sciences*, *3*(5), 136.

Jithendran, K.P. (2004). Seroprevalence of Toxoplasma antibodies in domestic animals- an indicator of Toxoplasma gondii in the environment and human. *ENVIS Bulletin Himalayan Ecology*, 12, 22–8.

Jittapalapong, S., Sangvaranond, A. & Pinyopanuwat, N. (2005). Seroprevalence of *Toxoplasma gondii* infection in domestic goats in Satun Province,Thailand. *Veterinary Parasitology*, *127*(1), 17–22.

Kaabia, N., Letaief, A. (2009). Q fever in Tunisia. *Pathology and Biology*, 57, 439–443.

Kamani, J., Mani, A.U., Godwin, O. & Egwu, G.O. (2010). Seroprevalence of *Toxoplasma gondii* infection in domestic sheep and goats in Borno state, Nigeria. *Tropical Animal Health and Production*, 42, 793-797.

Klaasen, M., Roest, H.J., Van der Hoek, W., Goossens, B., Secka, A. (2014). Coxiella burnetii Seroprevalence in Small Ruminants in The Gambia. *PLoS ONE 9*(1), e85424. doi:10.1371/journal.pone.0085424.

Mazyad, S.A.M., Hafez, A.O. (2007). Q fever (Coxiella burnetii) among man and farm animals in North Sinai, Egypt. *Journal of the Egyptian Society of Parasitology*, 37, 135–142.

Megersa, B., Biffa, D., Abunna, F., Regassa, A. & Godfroid J. (2010). Seroprevalence of brucellosis and its contribution to abortion in cattle, camel, and goat kept under pastoral management in Borana, Ethiopia. *Tropical Animal Health and Production*, 43, 651–656.

Mohammed, M., Mindaye, S., Hailemariam, Z., Tamerat, N. & Muktar, Y. (2017). Sero-Prevalence of Small Ruminant Brucellosis in Three Selected Districts of Somali Region, *Eastern Ethiopia, 5*(1), 1–6. https://doi.org/10.15744/2348-9790.5.105

Muema, J., Thumbi, S.M., Obonyo, M., Wanyoike, S., Nanyingi, M., Osoro, E., Bitek, A. & Karanja, S. (2017). Seroprevalence and factors associated with Coxiella burnetii infection in small ruminants in Baringo County, Kenya. *Zoonoses Public Health*, 64, e31-e43.

Muma, J.B., Samui, K.L., Siamudaala, V.M., Oloya, J. & Matop, G. (2006). Prevalence of antibodies to Brucella spp. and individual risk factors of infection in traditional cattle, goats and sheep reared in livestock-wildlife interface areas of Zambia. *Tropical Animal Health and Production*, 38, 195–206.

Nakoune, E., Debaere, O., Koumanda-Kotogne, F., Selekon, B. & Samory, F. (2004). Serological surveillance of brucellosis and Q fever in cattle in the Central African Republic. *Acta Tropica*, 92, 147–151.

Negash, T., Tilahun, G., Patton, S., Prevot, F. & Dorchies, P. (2004). Serological survey of toxoplasmosis in sheep and goats in Nazareth, Ethiopia. *Revue de Médecine Véterinaire*, 155, 486-487.

OIE, (2018). The center for food security and public health; African Animal Trypanosomiasis. www.cfsph.iastate.edu Email: cfsph@iastate.edu.

OIE. (2009). Terrestrial Manual 2009; Bovine brucellosis. 2:4-3.

OIE. (2015). Q Fever OIE Terrestrial Manual 2015; Oce International des Epizootics: Paris, France, pp. 1–15.

Opsteegh, M., Teunis, P., Mensink, M., Zuchner, L., Titilincu, A., Langelaar, M. & Van Der Giessen, J. (2010). Evaluation of ELISA test characteristics and estimation of *Toxoplasma gondii* seroprevalence in Dutch sheep using mixture models. *Preventive Veterinary Medicine*, 96, 232-240.

Paul, S., Agger, J.F., Markussen, B., Christoersen, A.B. & Agerholm, J.S. (2012). Factors associated with Coxiella burnetii antibody positivity in Danish dairy cows. *Preventive Veterinary Medicine*, 107, 57–64.

Peter, I.D., Dauda, Y., Thlama, P.B., Ndahi, J.J., Madziga, H.A., Stephen, J., & Mustapha, A. (2015). A retrospective study of small ruminant diseases identified at the State Veterinary Hospital Maiduguri, Nigeria. *J. Anim. Health Prod.*, *3*(4), 88-93.

Peters, (1994). Major animal production constraints in sub-Saharan Africa countries.

Philip, C.B., Hoogstraal, H., Reiss-Gutfreund, R. & Clifford, C.M. (1966). Evidence of rickettsial disease agents in ticks from Ethiopian cattle. *Bull. World Health Organazation*, 35, 127–131.

Qudrat, U., Hosny, E., Tariq, J., Huma, J., Zafar, I.Q., Muhammad, S., Shakeeb, U., Muhammad, K.S., Alam, Z.K., Muhammad, Z., Iahtasham, K., Katja, M., Klaus, H. & Heinrich, N. (2019). Serological and Molecular Investigation of Coxiella burnetii in Small Ruminants and Ticks in Punjab, Pakistan. *International Journal of Environmental Research in Public Health*, 16, 4271. doi: 10.3390/ijerph16214271 www.mdpi.com/journal/ijerph.

Radostits, O.M., Gay, C., Blood, D.C. & Hinchclift, K.W. (2007). Veterinary Medicine: a text book of the Disease of cattle, sheep, pigs, goats and horse. Harcourt publishers limited, London, 882-885.

Radostits, O.M., Gay, C.C., Hinchcliff, K.W. & Constable, P.D. (2006). Veterinary medicine: *a textbook of the diseases of cattle, horses, sheep, pigs and goats*. 10th ed. London: Sounders, 1518–22.

Rizzo, F., Vitale, N., Ballardini, M., Borromeo, V., Luzzago, C., Chiavacci, L. & Mandola, M. L. (2016). Q fever seroprevalence and risk factors in sheep and goats in northwest Italy. *Preventive Veterinary Medicine*, 130, 10–17.

Sanchez, J., Souriau, A., Buendia, A.J., Arricau-Bouvery, N., Martinez, C.M., Salinas, J. Rodolakis, A. & Navarro, J.A. (2006). Experimental Coxiella burnetii infection in pregnant goats: A histopathological and immunohistochemical study. *Journal of Comparative Pathology*, 135, 108–115.

Schelling, E., Diguimbaye, C., Daoud, S., Nicolet, J. & Boerlin, P. (2003). Brucellosis and Q-fever seroprevalences of nomadic pastoralists and their livestock in Chad. *Preventive Veterinary Medicine*, 61, 279–293.

Shaapan, R.M., Hassanam, M.A. & Khahl, F.A.M. (2010). Modified agglutination test for serologic survey of Toxoplasma gndii infection in goats and water buffaloes in Egypt, *Research Journal of Parasitology*, *5*(1), 13–17.

Steinmann, P., Bonfoh, B., Peter, O., Schelling, E. & Traore, M. (2005). Seroprevalence of Q-fever in febrile individuals in Mali. *Tropical Medicine and International Health*, 10, 612–617.

Swai, E.S., Kaaya, J.E. (2013). A survey of *Toxoplasma gondii* antibodies by latex agglutination assay in dairy goats in Northern Tanzania. *Tropical Animal Health and Production*, 45, 21-217.

Szeredi, L., Jánosi, S., Tenk, M., Tekes, L., Bozsó, M., Deim, Z. & Molnár, T. (2006). Epidemiological and pathological study on the causes of abortion in sheep and goats in Hungary (1998-2005). *Acta Veterinaria Hungarica, 54*(4), 503–515.

Tadesse, G. (2016). Brucellosis Seropositivity in Animals and Humans in Ethiopia: A Meta-analysis. *PLoS Neglected Tropical Diseases, 10*(10), e0005006. https:// doi.org/ 10.1371/ journal.pntd.0005006

Tegegne, D., Abdurahaman, M., & Yohannes, M. (2016). Seroepidemiology and associated risk factors of Toxoplasma gondii in sheep and goats in Southwestern Ethiopia. *BMC Veterinary Research*, *12*(1), 1-6.

Teklye, B., Kasali, O. (1989). The prevalence of brucellosis in small ruminants in central Ethiopia. *Bulletin of Animal Health and Production in Africa*, 37, 97–98.

Tenter, A.M., Heckerotha, A.R. & Weiss, L.M. (2000). Toxoplasma gondii: from animals to humans. *International Journal of Parasitological*, 30, 1217–58.

Teshale, S., Dumetre, A., Dardé, M.L., Merga, B. & Dorchies, P. (2007). Serological survey of caprine toxoplasmosis in Ethiopia: Prevalence and risk factors. *Parasitology*, 14, 155-159.

Teshale, S., Yibeltal, M., Abaineh, D. & Awoke, K. (2006). Seroprevalence of small ruminant brucellosis in selected districts of Afar and Somali pastoral areas of eastern Ethiopia: the impact of husbandry practice. *Revue de Medicine Veterinaire*, 157, 557–563.

Teshome, H., Molla, B. & Tibbo, M. (2003). A seroprevalence study of camel brucellosis in three camel-rearing regions of Ethiopia. *Tropical Animal Health and Production*, 35, 381–390.

Tilahun, B., Tolossa, Y.H., Tilahun, G., Ashenafi, H., & Shimelis, S. (2018). Seroprevalence and risk factors of Toxoplasma gondii infection among domestic ruminants in East Hararghe zone of Oromia Region, Ethiopia. *Veterinary Medicine International*, Article ID 4263470.

Ullah, Q., Jamil, H., Iqbal Qureshi, Z., Saqib & Neubauer, H. (2018). Sero-epidemiology of Q Fever (Coxiellosis) in small ruminants kept at government livestock farms of Punjab, Pakistan. *Pakistan Journal of Zoology*, 51, 135–140.

Van Der Puije, W.N.A., Bosompem, K.M., Canacoo, E.A., Wastling, J.M. & Akanmori, B.D. (2000). The prevalence of anti-Toxoplasma gondii antibodies in Ghanaian sheep and goats. *Acta Tropica*, 76, 21-26.

Yizengaw, L., Belayneh, N., Zegeye, A., Tesema, Z., Kefale, A., Kiross, S. & Shibesh, M. (2020). Retrospective Analysis of Clinical Cases of Caprine and Ovine in Sirinka Agricultural Research Centre, Amhara Region. *Proceedings of the 12th Annual Regional Conference on Completed Livestock Research Activities*, Bahir Dar, Ethiopia.

Zegeye, A., Belayineh, N., Shenkutie, A., Lakew, M. & Tesfaye A. (2014). On-Station Retrospective Epidemiologic Study of Small Ruminant Disease in Sirinka Agricultural Research Center, Sheep and Goat Breeding, Evaluation and Distribution Site. Academic *Journal of Animal Diseases, 3*(3), 39-44.

Zewdu, E., Agonafir, A., Tessema, T.S., Tilahun, G., Medhin, G., Vitale, M., Di Marco, M. V,. Cox, E., Vercruysse, J. & Dorny, P. (2013). Seroepidemiological study of caprine toxoplasmosis in East and West Shewa Zones, Oromia Regional State, Central Ethiopia. *Research in Veterinary Science*, 94, 43-48.

Zinsstag, J., Schelling, E., Solera, X., Blasco, J. & Moriyon I. (2011). Brucellosis; *Oxford Textbook of Zoonoses*, 54-64.